POLE FRAME CONSTRUCTION

NATIONAL ASSOCIATION OF FOREST INDUSTRIES

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COVER PHOTO: Pole Frame construction has been used extensively in this alpine village resort

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Two level recreation complex features 300 mm diameter hardwood poles

The central pole supports staircase in this observation tower

The information, opinions, advice and recommendations contained in this Datafile have been prepared with due care. They are offered only for the purpose of providing useful information to assist those interested in technical matters associated with the specification and use of timber and timber products.

Whilst every effort has been made to ensure that this Datafile is in accordance with current technology, it is not intended as an exhaustive statement of all relevant data, and as successful design and construction depends upon numerous factors outside the scope of this Datafile, the National Association of Forest Industries Ltd accepts no responsibility for errors in, or omissions from, the Datafile, nor for specifications or work done or omitted to be done in reliance on this Datafile.

Introduction

Round timber construction has been used extensively since Australia's early settlement. From simple housing construction to major structures such as industrial buildings and massive wool sheds, timber played an important role in the development of a unique building tradition.

Pole frame construction is not new. It had been used for many centuries to construct tall buildings, particularly to resist earthquakes. Many significant structures built more than 800 years ago are still standing today in many parts of the world. Although the modern pole frame construction system is recognised mainly for its use in housing, it can be used to create a natural architectural character and an economical structure for a wide range of applications including:

- churches
- restaurants
- recreation halls
- tourist resorts
- hotels
- industrial buildings
- rural sheds
- housing

Timber technology has responded to the contemporary needs of building construction. Developments in stress grading, seasoning and joining of sawn timber has provided joists and bearers capable of spanning large distances.

Also the development of preservative treatment processes has lead to an increase in the availability of timbers that are resistant to fungi and insects.

The advantages of a pole frame structure include:

- minimum site disturbance.
- minimum foundation requirements on reactive sites.
- simple post and beam construction.
- design flexibility.
- architectural harmony with natural environment.
- adaptable to sloping or steep sites.
- flexibility for earthquake and high wind design.

Cosy dining area surrounded by red-ironbark poles (400 mm diameter) supporting exposed roof system and mezzanine floor

Scope

The use of timber poles offers a choice of building methods to suit a variety of needs, particularly in relation to problem sites. Pole construction has developed into two basic types:

- Pole Platform Construction
- Pole Frame Construction

Pole platform construction allows conventional framed construction techniques above floor level, whereas in pole frame construction, the poles act as columns, from the foundation to the roof.

Refer Figure 1.

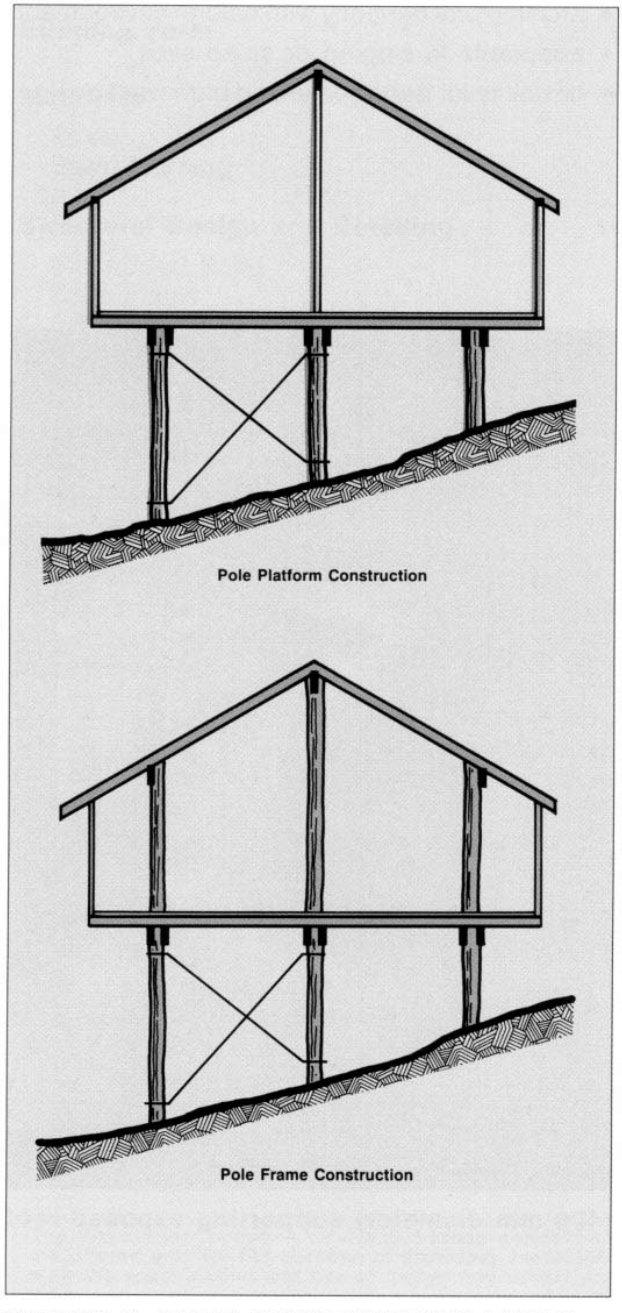


FIGURE 1 POLE CONSTRUCTION TYPES

The pole columns in both construction systems can be either embedded in the ground or pinned and supported on concrete footings. Refer Figure 2. Although pole construction has wide application, this datafile covers mainly pole frame construction, but where appropriate, includes details for pole platform construction.

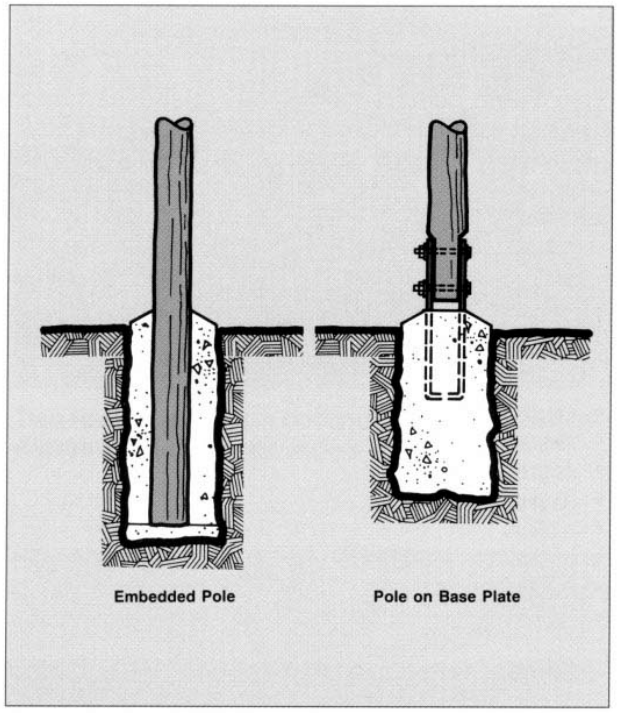


FIGURE 2 FOUNDATION TYPES

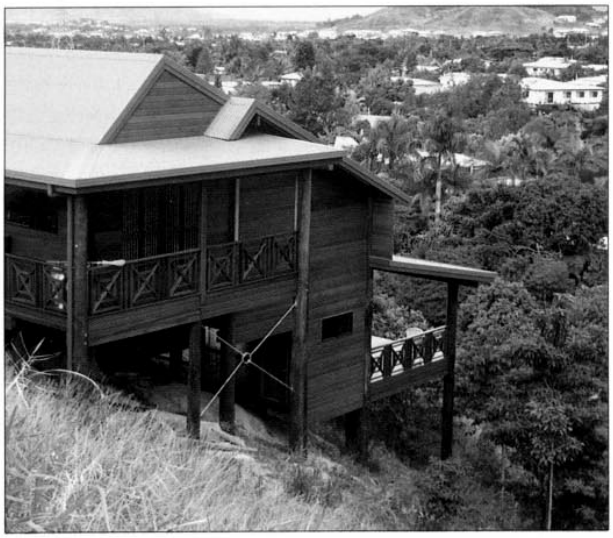
Design Considerations — Structural

The structural reasons for building a pole structure are often bound up in the geomechanics of the site i.e. the stability of the ground.

Steep Sites

Pole frames touch the earth at relatively few points, ensuring the integrity of the soil mass, while footings can penetrate the often unstable top soil and provide a good foundation in the more stable underlying layers. Very little load is added to the site ensuring minor alteration to the factor of safety against slipping. It is suggested however, that a Geotechnical Engineer be engaged to report on both the foundation and the stability of the slope before the design is finalised. Steep terrain may expose a structure to the full fury of the weather. The rising ground accelerates the wind and there is usually little opportunity for the building to be shielded by other structures. As a result, the structure may have to be designed for a higher wind speed than usual. Refer to AS 1170, Part 2 — SAA LOADING CODE — WIND FORCES.

Increased forces may necessitate stronger fastenings, larger studs, roof beams and rafters, thicker window glass, and increased bracing. Sloping sites may present difficulties in excavation of the foundations and the erection of the poles. Construction equipment access, or lack of it, should be considered at the feasibility stage.



Pole frame structures are well suited to steep terrain

Reactive Foundations

A reactive foundation is essentially a clay that significantly changes volume in response to moisture content variation. If a structure is founded on this material then, it too experiences this movement. If the elements in the building are brittle and the moisture distribution non-uniform, then the resulting differential movement will result in damage to the building fabric. The effects of a reactive site can be mitigated by using building materials that are more flexible. Timber and timber products are excellent in this regard. Swelling pressures can be resisted by increasing the foundation pressure, using a relatively small footing such as in a pole frame. Foundations can be made at a depth where the seasonal moisture variation is minimal. Pole frame construction can satisfy these requirements.

On extreme sites foundations are taken down to the stable layer (often 2.4 m down) and where embedded poles are used, the pole is coated with a slip layer of thick bitumen. This ensures that adhesion between the pole and the swelling top layers of clay is minimal. It is important that moisture is not encouraged by the construction process to enter the soil deeper than before. That is, the stable level must be preserved. A design method is suggested by McAnally (Ref 20).

Low Bearing Pressure Foundations

Land that has a low bearing capacity includes swamps and marsh lands, very soft clays and filled sites where the strength of the soil is low or the compaction has been so minimal that consolidation (settlement) will continue to occur for some time. For the swamps and soft clays, either the poles have to be founded on firmer soil that is to be found with depth, or the support generated by the development of skin friction. For the unconsolidated sites, such as refuse tips and ash dumps, the support can only be generated by end bearing. Driven poles (piles) are generally used on sites with poor soil, combined with high water table, where the alternative bored footing could only be formed by using an expensive liner to prevent collapse of the soil during excavation. In order that the maximum skin friction is developed, these piles are driven small end down, whereas potted piles are invariably placed butt end down, as this puts the strongest (and stiffest) part of the pile where it is needed. For bored footings, bearing pressure can be diminished by reducing the grid spacing of the poles or by increasing the concrete pads under the poles. Reference should be made to AS 2159, SAA PILING CODE.

Design Considerations — Functional

Design Flexibility

Since the poles carry all the vertical loads the walls are simply partitions that may be located virtually anywhere. With a double bearer system, the poles are spaced farther apart than is usual, creating a building interior that is more spacious allowing flexibility in the interior design. The poles and beams themselves contribute to the "feel" of the structure which may be a series of rooms or completely open plan (consistent with bracing requirements). The components, being larger, are fewer, and as a result, the floors can be completed quickly. The poles are usually placed to a grid but the adaptability of the system does not preclude a variety of placements. The system can be readily engineered using familiar design principles. In high wind areas the poles can provide the necessary tie-down.

Harmony with Natural Environment

Being a natural material, timber will complement architectural design aimed to harmonise with the natural environment. The small number of footings necessary to support the structure provides minimum disturbance to the natural site condition. Pole frames are often constructed within a treed environment and adequate clearance between the swaying trunks and branches and the structure should be allowed. Further precautions should be followed in bushfire prone areas and recommendations are detailed in Bushfire Resistant Housing by the Timber Promotion Council — Victoria. A pole structure may be built over permanent water. Where this water is brackish, too salty, steps must be taken to guard against attack from various marine organisms within the tidal range.

Double treated piles (creosote and copper chrome arsenate) or those with barriers such as epoxy coatings, copper or concrete shields provide effective resistance to this hazard. These wood eating animals are more aggressive the warmer the water, so less extensive treatment is required in the non-tropical regions (Ref 10 and 11). Reference also should be made to Datafile P4, TIMBER — DESIGN FOR DURABILITY.

Outlook

Designers often orient glazing to take full advantage of the view, but glass does not contribute to the strength of the building. Solid wall bracing or cross-bracing has to be installed in both directions but bracing poles may also be used. Designers may emphasise the cross-bracing at windows with little loss of view and this solution may be a preferred to the use of smaller windows combined with the equivalent sheet bracing wall. The effect of structural flexibility on rigid glass panels will need to be considered.

Serviceability

The common use of pole structures on exposed sites raises the likelihood of water penetration from driving rain. More attention to flashing is required, especially around openings and corners and to penetrations through the cladding for joists and bearers. Consideration should also be given to sarking under all the wall cladding with a vapour permeable building paper (NOT foil or plastic). Where roofs offer little protection from the weather, windows are especially vulnerable. Hoods shielding the opening from the rain could be considered. Awning type windows also offer some assistance in this regard. The hoods can also provide a measure of sun control. The structure can also be exposed to extremes of sun, causing drying of timbers and reducing the life of all paint systems. Opaque paint systems protect timber best and lighter colours absorb less light and, as a result, the paint maintains its integrity for a longer period (Refer Datafile FM1, EXTERIOR FINISHES FOR TIMBER). Maintenance practices have to be considered at the design stage. These include access for:

- roof cleaning
- cleaning eaves gutters
- window cleaning
- re-painting

Building Form

The simple pole and beam principle of pole frame construction is extremely adaptable to architectural expression. Regular or irregular placement of poles and the variable relationship of poles and walls can provide selections of building form to satisfy diverse design requirements. Figures 3 and 4 illustrate a range of possible variables.

Metal, tiles or shingles can be used for roofing but high roof pitches magnify the racking forces. A structure with limited room for bracing elements, such as one with lots of glass, is most efficient with a roof less than 15°. There is a substantial increase in racking forces for roof pitches over 25° and structures with gable ends. Pole frames are often very tall and so, for construction as well as for maintenance of the roof and gutter, ease of access should be considered.

High roof areas will exhibit a significant temperature range with the attic levels being quite warm at the expense of the lower areas. While advantage may be taken of this, consideration should be given to venting the top levels during summer to prevent excessive heat build up. Various roof vents and turbines, throttled by dampers, may be installed in the roof to allow a degree of environmental control. The roof overhang should be given special consideration. The overhang can protect the pole connections, cladding and windows, reducing maintenance.

Pole frames may be placed external to the walls to enhance the architectural effect or, alternatively, the poles may be expressed internally. Refer Figure 5. External poles expose the connections, pole timber and bearer to the weather and, as a result more attention has to be given to durability and flashing at bearers and floor joists. In the internal system, poles of lower durability may be used provided that they are mounted on base plates. In this protected environment seasoned joists and bearers may be utilised. This means that shrinkage problems are all but eliminated and the capacity of the bearer-pole connection is greatly enhanced. Poles may be set within the walls provided that detailing for pole shrinkage ensures that the walls remain weather proof. In this application windows and doors are best kept some distance away from the poles.

On the one hand, room sizes in pole frames dictate pole spacings, as it is usually unacceptable to have a pole passing through the middle of a room. Also the cost of the foundation and poles tend towards using as few poles as possible. On the other hand, the increased sizes of both the bearers and joists to accommodate the increased spans, together with the strength limitation of the bearer-pole connection, dictate the upper bound to the construction grid. The economics of pole framed building is strongly influenced by the bearer-pole connection and so consideration of this joint is often the first step in the structural design.

Embedded pole sizes are generally based on their deflection in response to lateral load so that they may supply at least some of the racking resistance. However connections that are cut into the pole can have a significant effect on the pole strength. Where poles are fixed to base plates, the pole size is usually more than adequate for the design loads.

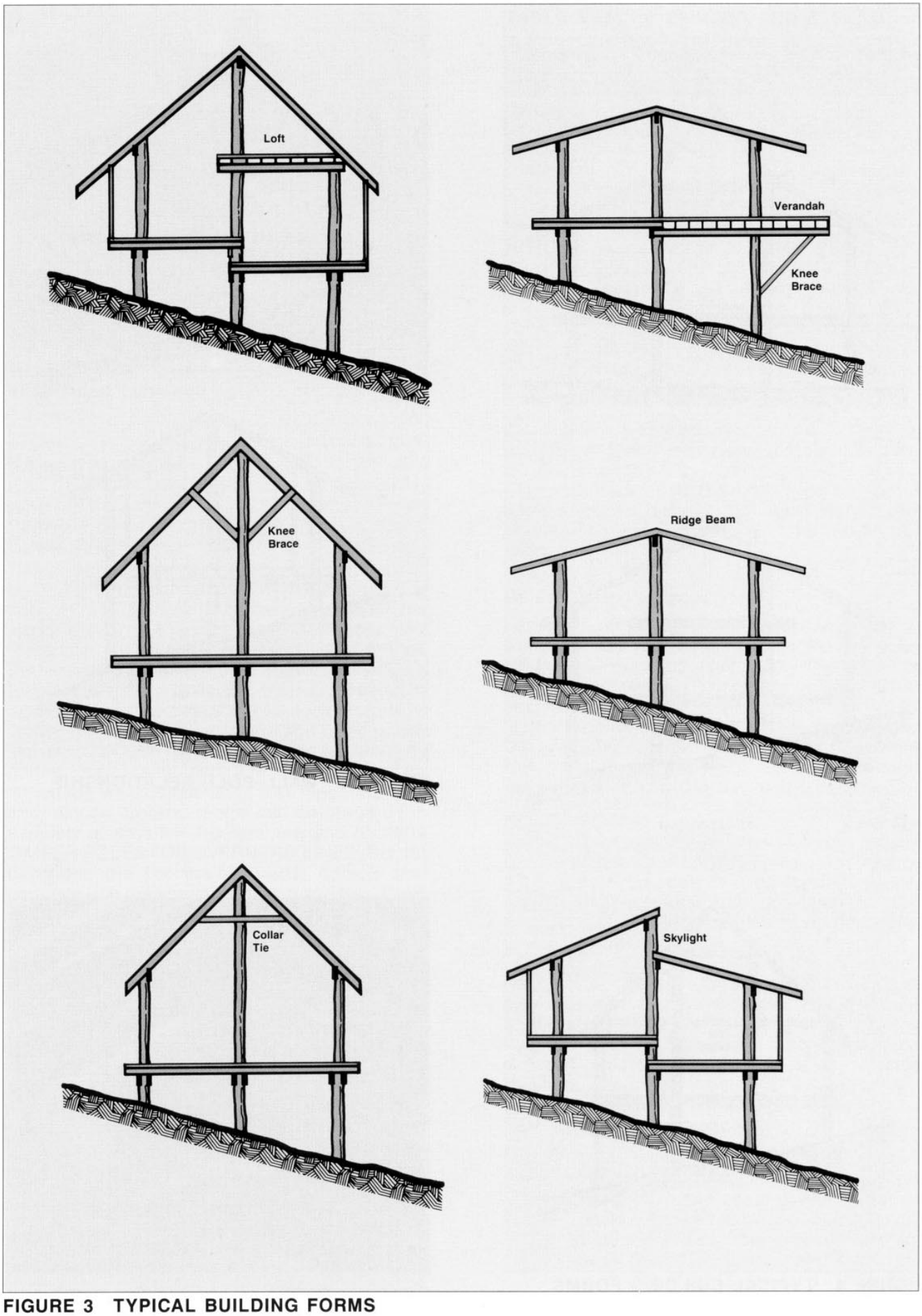


FIGURE 3 TYPICAL BUILDING FORMS

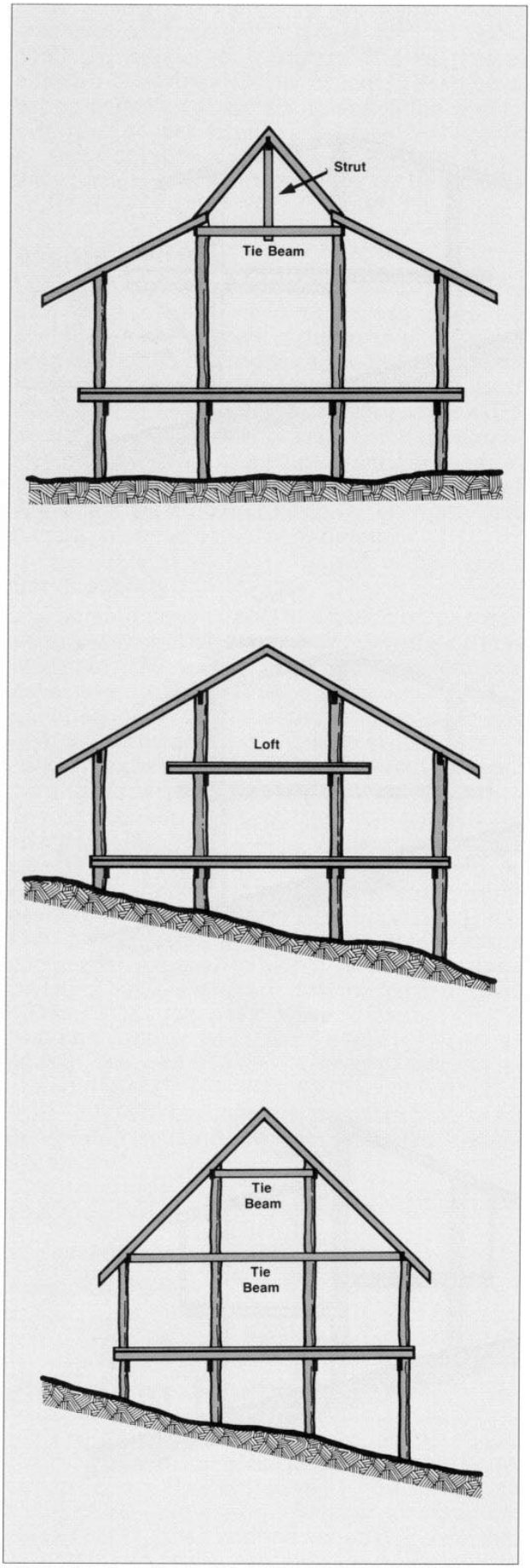


FIGURE 4 TYPICAL BUILDING FORMS

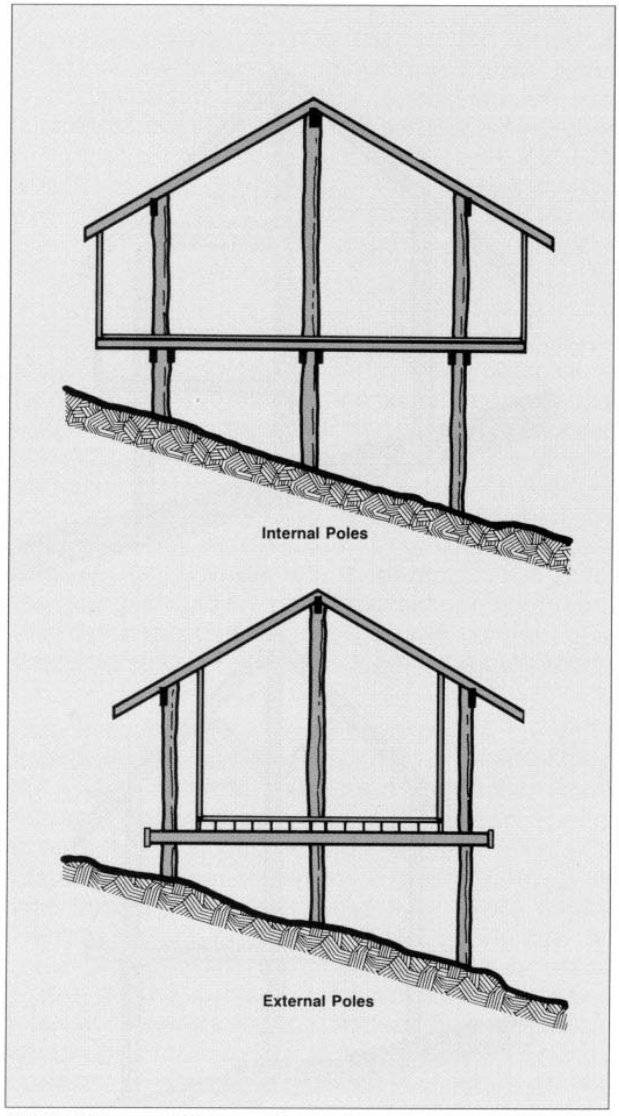


FIGURE 5 WALL–POLE RELATIONSHIP

Poles supporting mezzanine floor and roof structure